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Morris et al.

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(54) **OBSTRUCTION DETECTION DEVICE FOR VEHICLE DOOR AND METHOD**

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G06F 7/00 (2006.01)

(52) **U.S. Cl.** **701/49**; 701/36; 701/45; 340/901; 49/26

(58) **Field of Classification Search** 701/33, 701/36, 45, 49; 340/540, 901; 318/264, 318/480, 445; 49/26, 28
See application file for complete search history.

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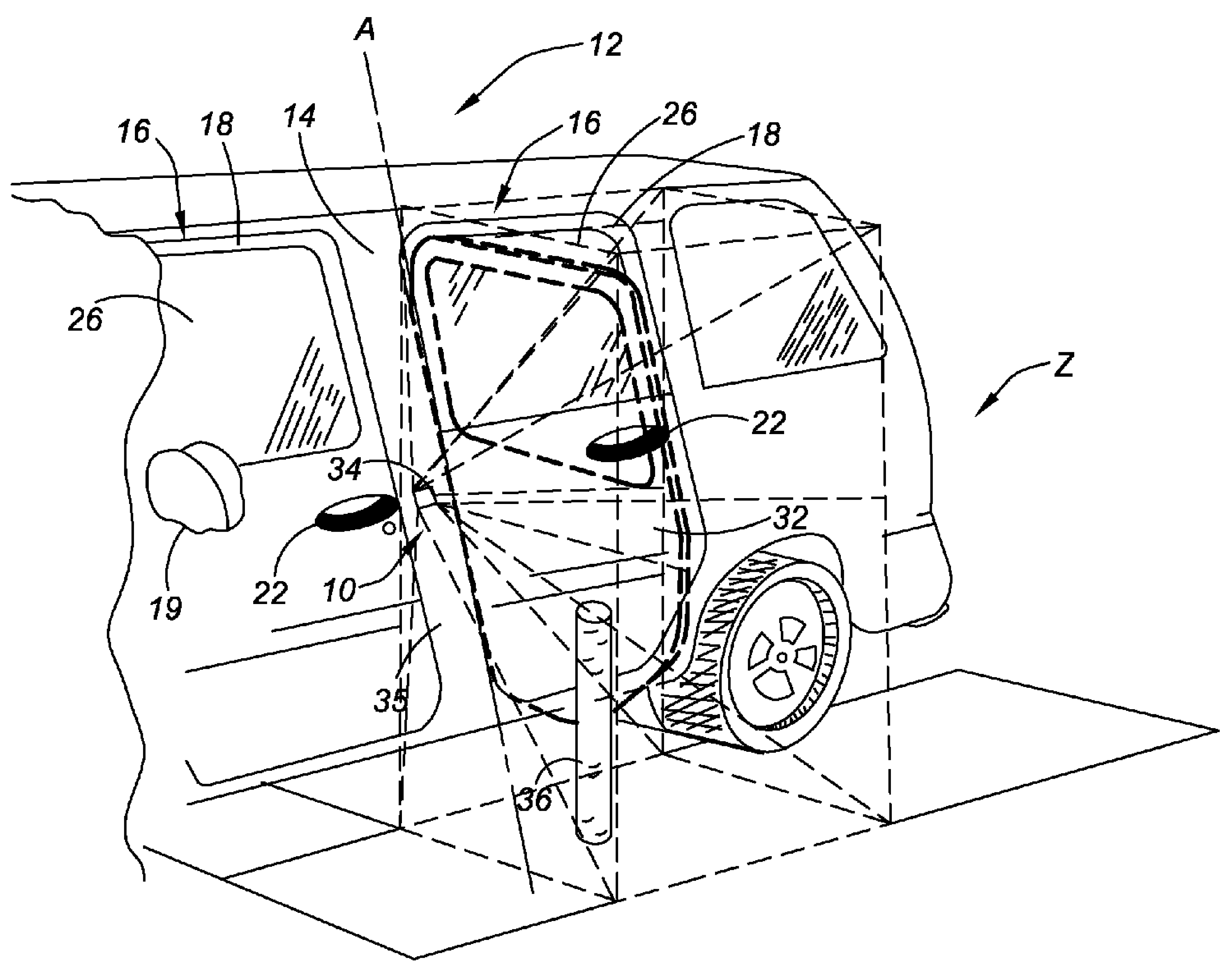
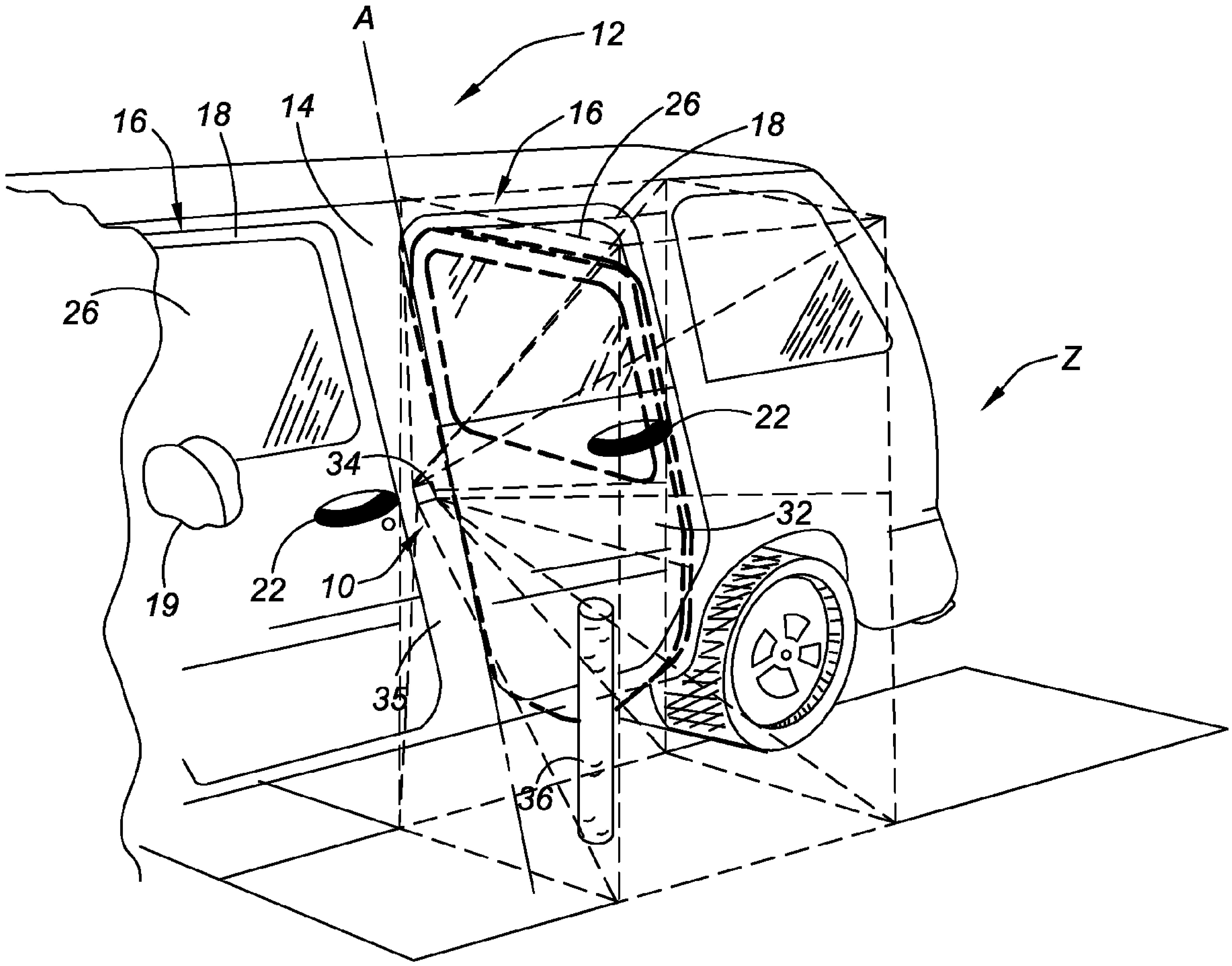
(57) **ABSTRACT**

An obstruction detection device for a motor vehicle having a door assembly movably connected to a vehicle body is provided. The device controls the vehicle door's opening angle to prevent inadvertent contact with an object foreign to the vehicle, while providing the largest opening for vehicle ingress and egress. The obstruction detection device includes a controller that is operatively connected to at least one sensor configured to actively monitor and transmit signals to the controller indicative of the presence and corresponding proximity of the object relative to the door assembly. An actuator is operatively connected to and controlled by the controller. The actuator is configured to apply a selectively variable force that restricts the movement of the vehicle door assembly with respect to the vehicle body when the door is a predetermined distance from the object.

25 Claims, 7 Drawing Sheets




A
12
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18
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16
26
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26
Z
22
34
32
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22
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35
36

FIG. 1a

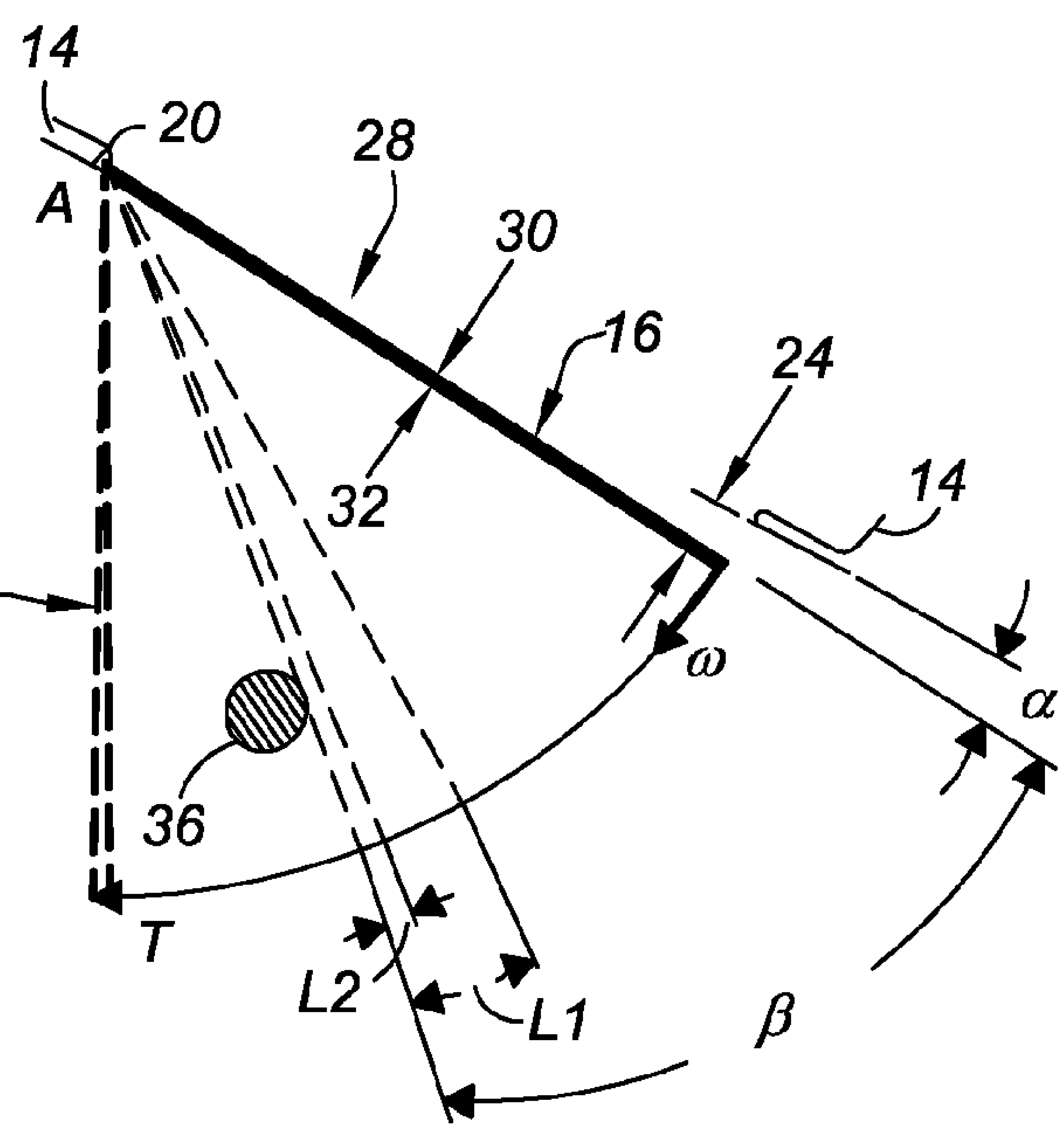
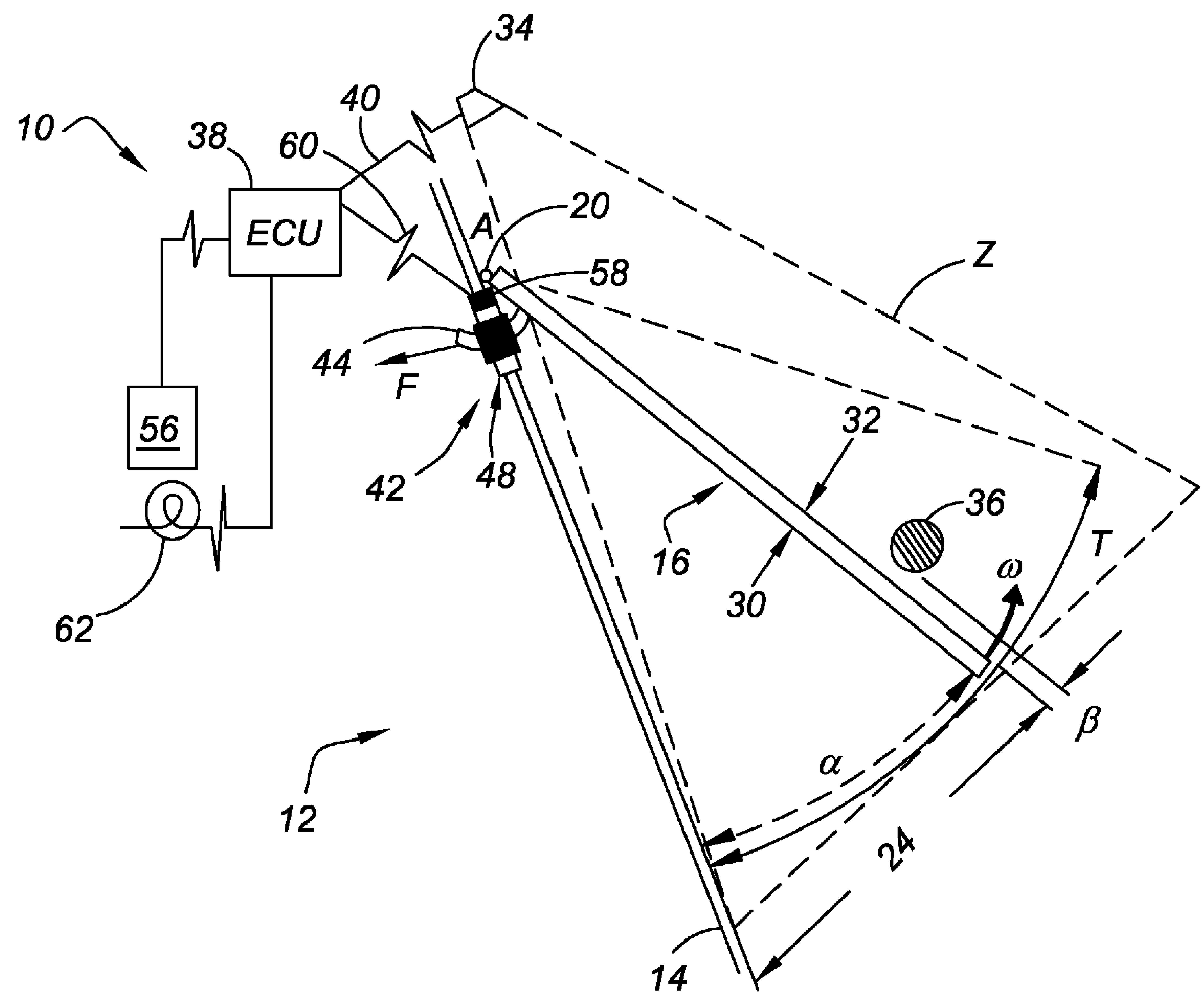
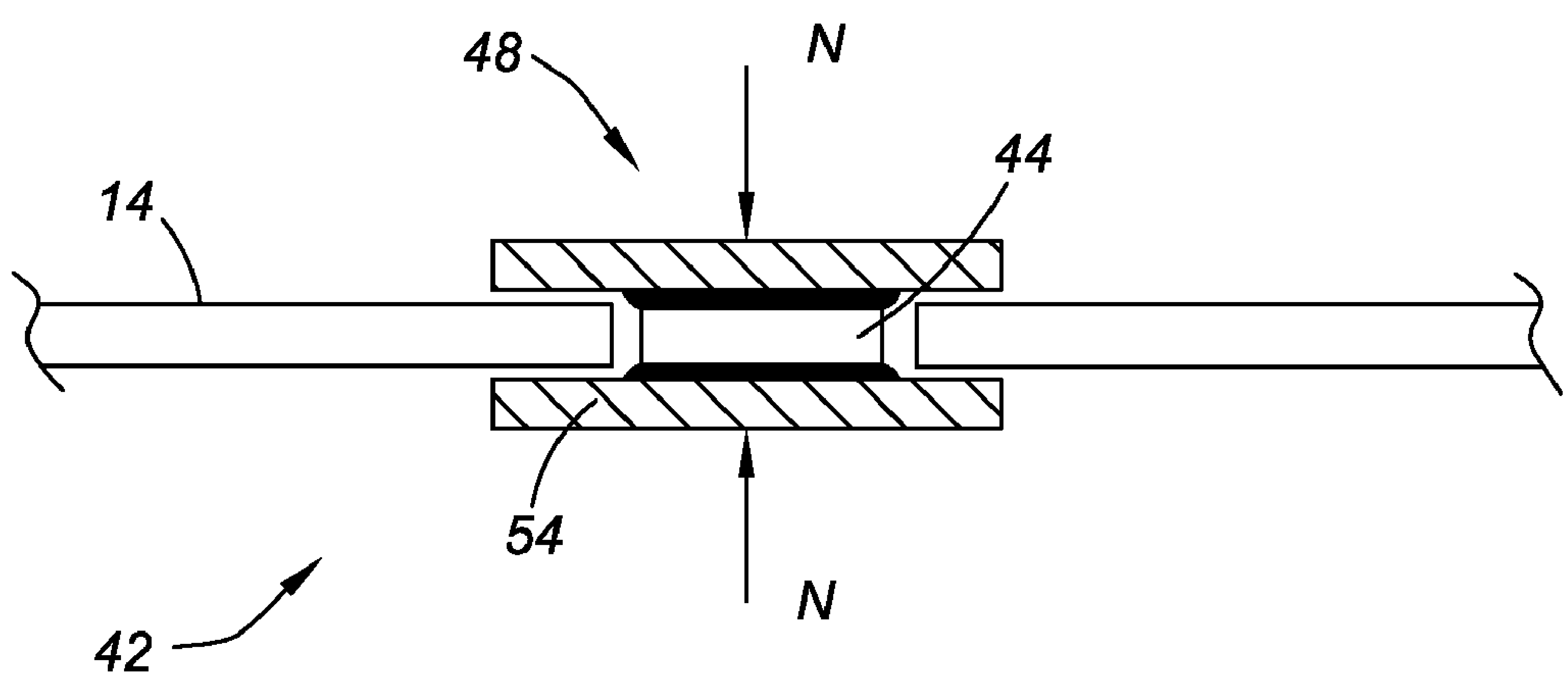

14
20
A
28
30
16
24
14
32
16
ω
α
36
T
L2
L1
β

FIG. 1b



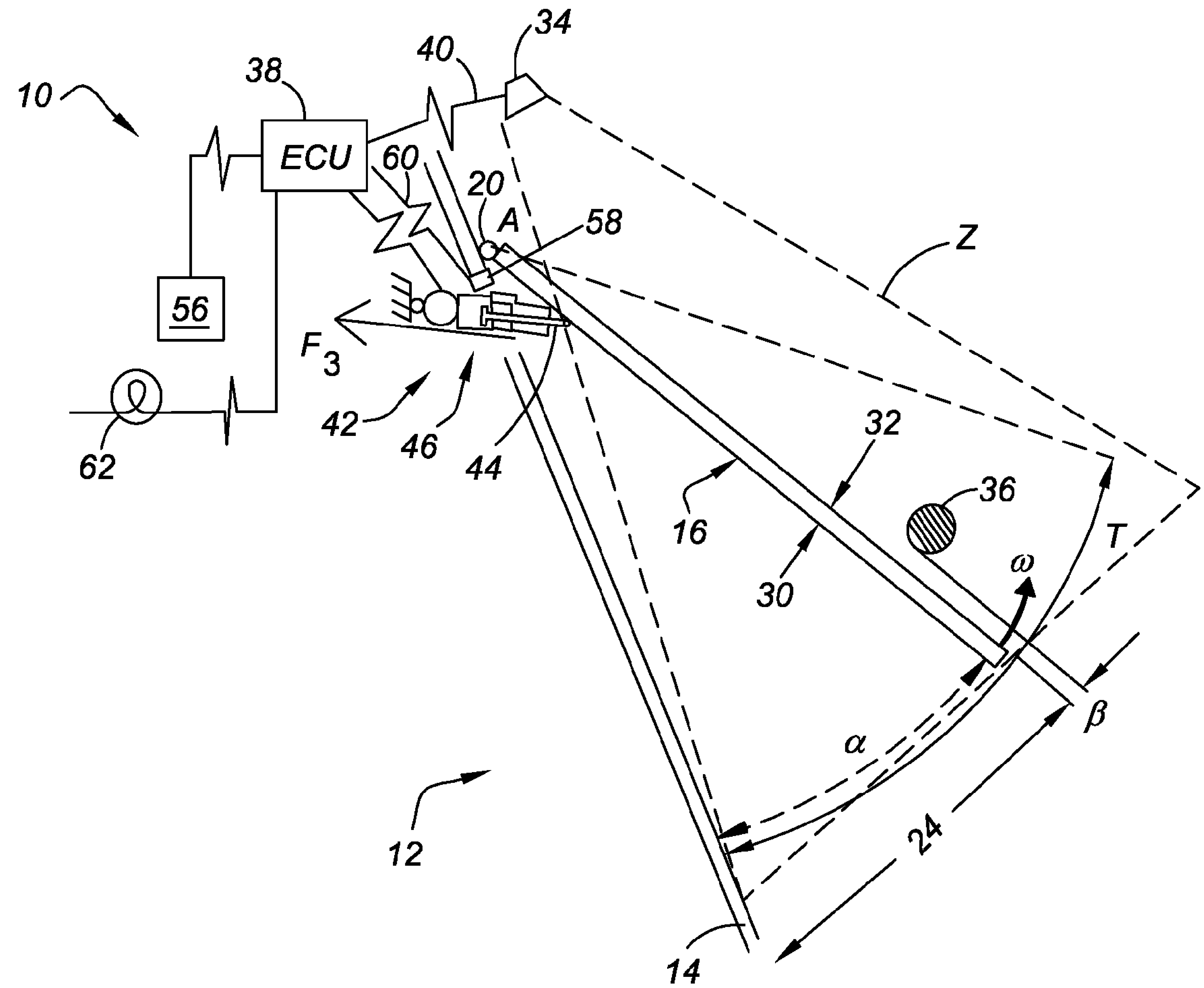
10
38
40
60
34
ECU
A
20
58
Z
44
F
42
48
56
32
36
T
16
30
ω
62
β
α
12
24
14

FIG. 2a



48
N
44
14
54
N
42

FIG. 2b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38
ECU
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20
A
58
Z
56
F3
42
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44
62
32
36
16
30
T
ω
β
α
24
12
14

FIG. 3a

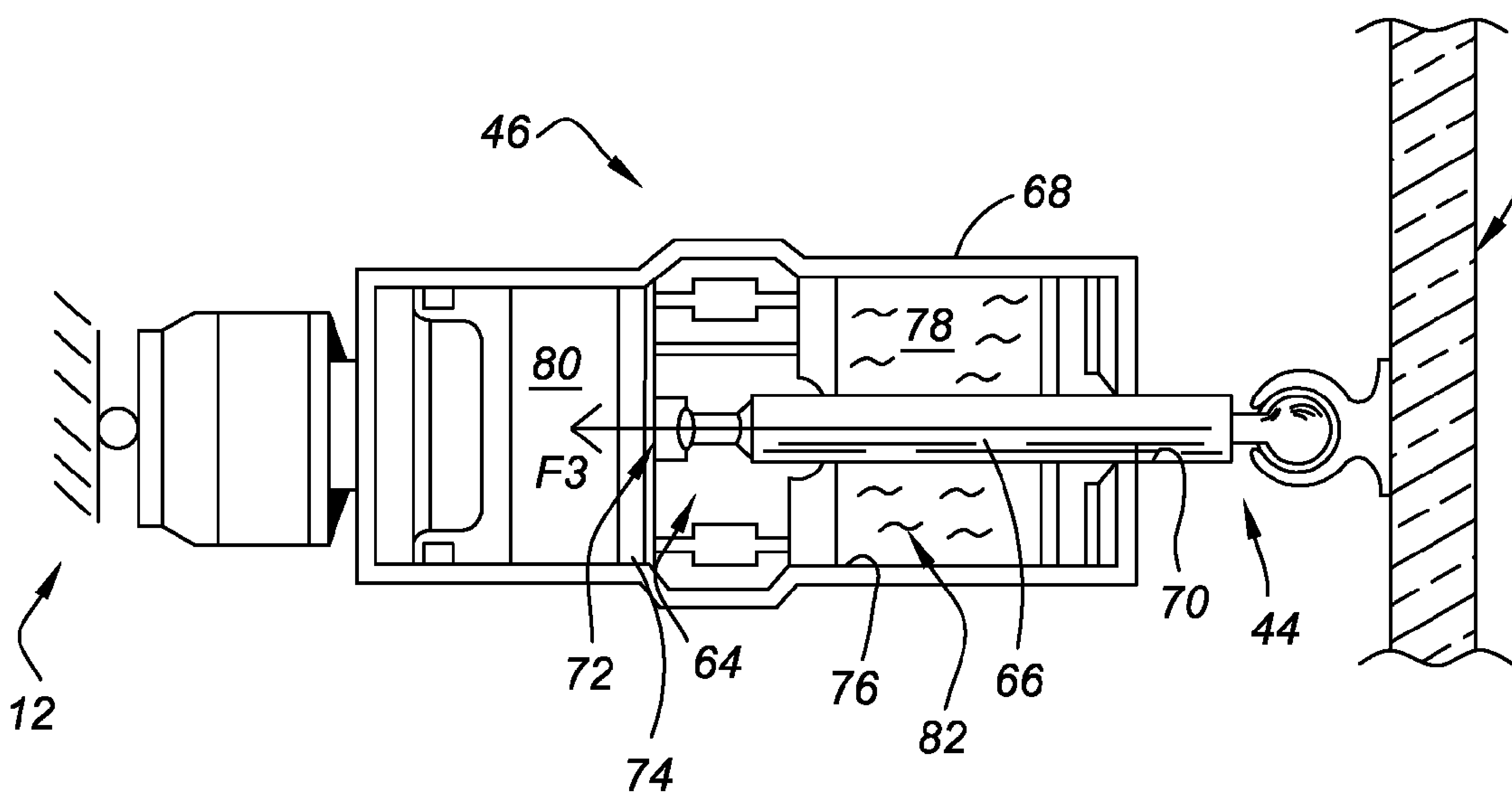
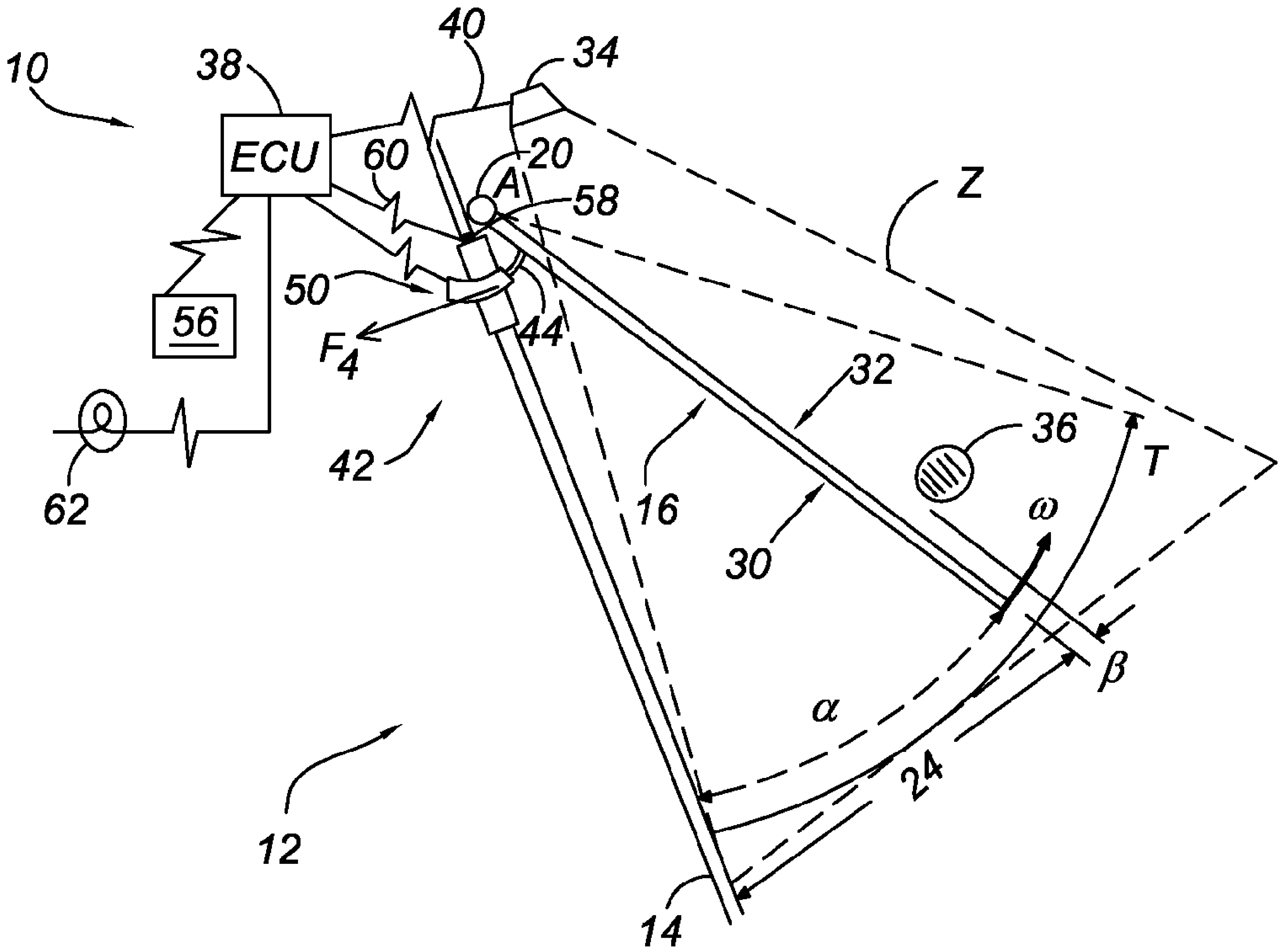

46
68
16
78
80
F3
12
72
74
64
76
82
66
70
44

FIG. 3b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A
58
Z
50
44
F4
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42
36
T
16
62
56
30
ω
β
α
24
12
14

FIG. 4a

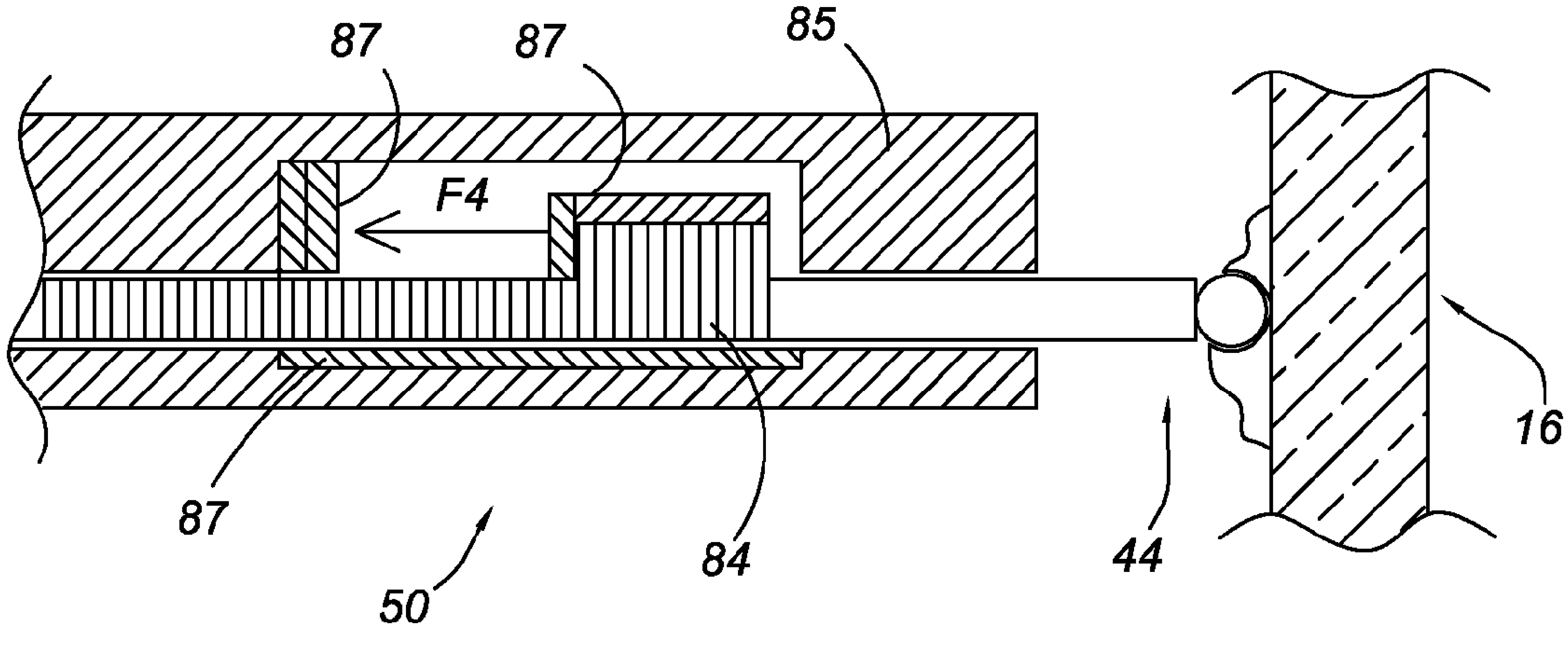
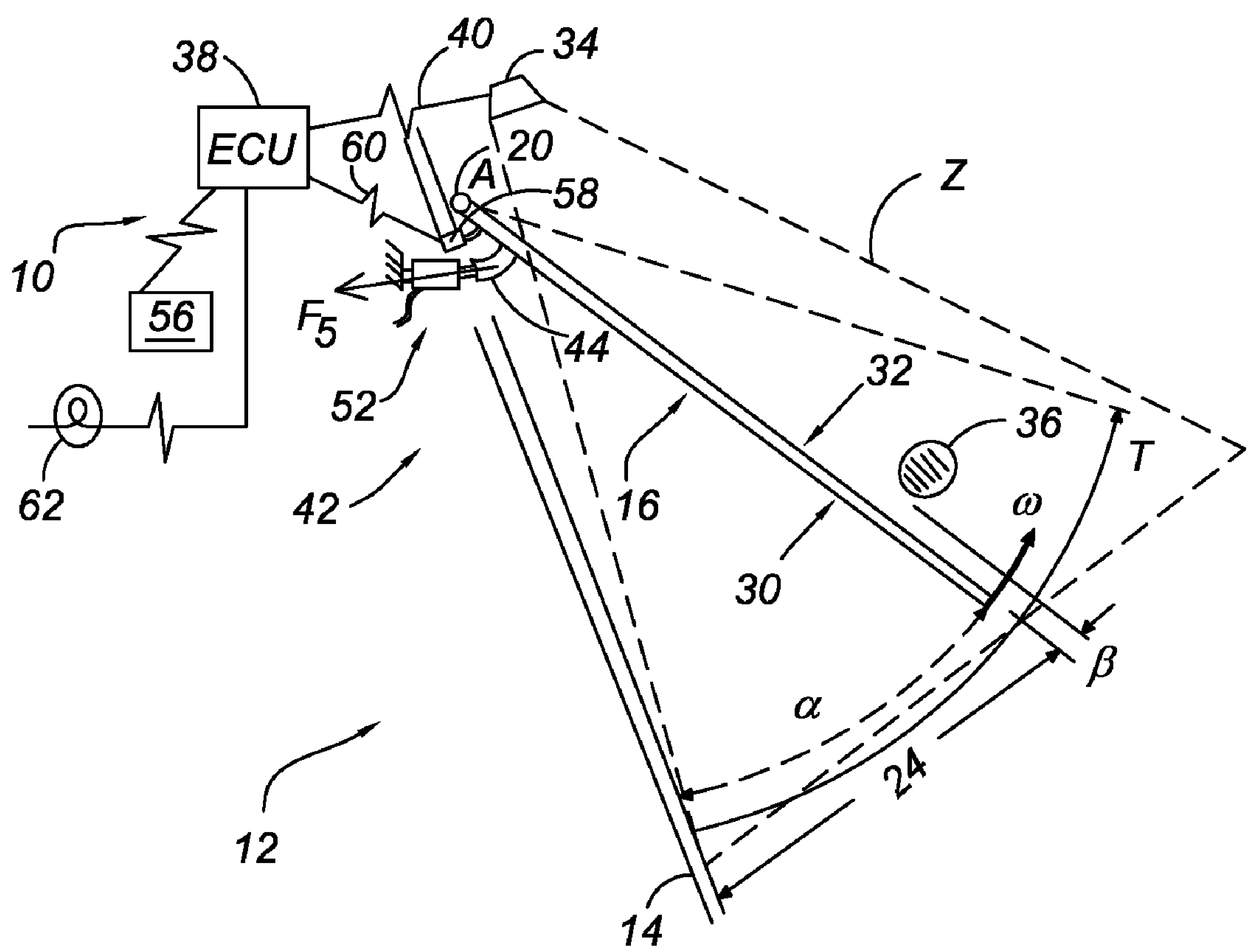

87
87
85
F4
16
87
84
44
50

FIG. 4b


38
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A
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Z
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56
F_5
44
32
52
36
T
62
42
16
ω
30
β
α
24
12
14

FIG. 5a

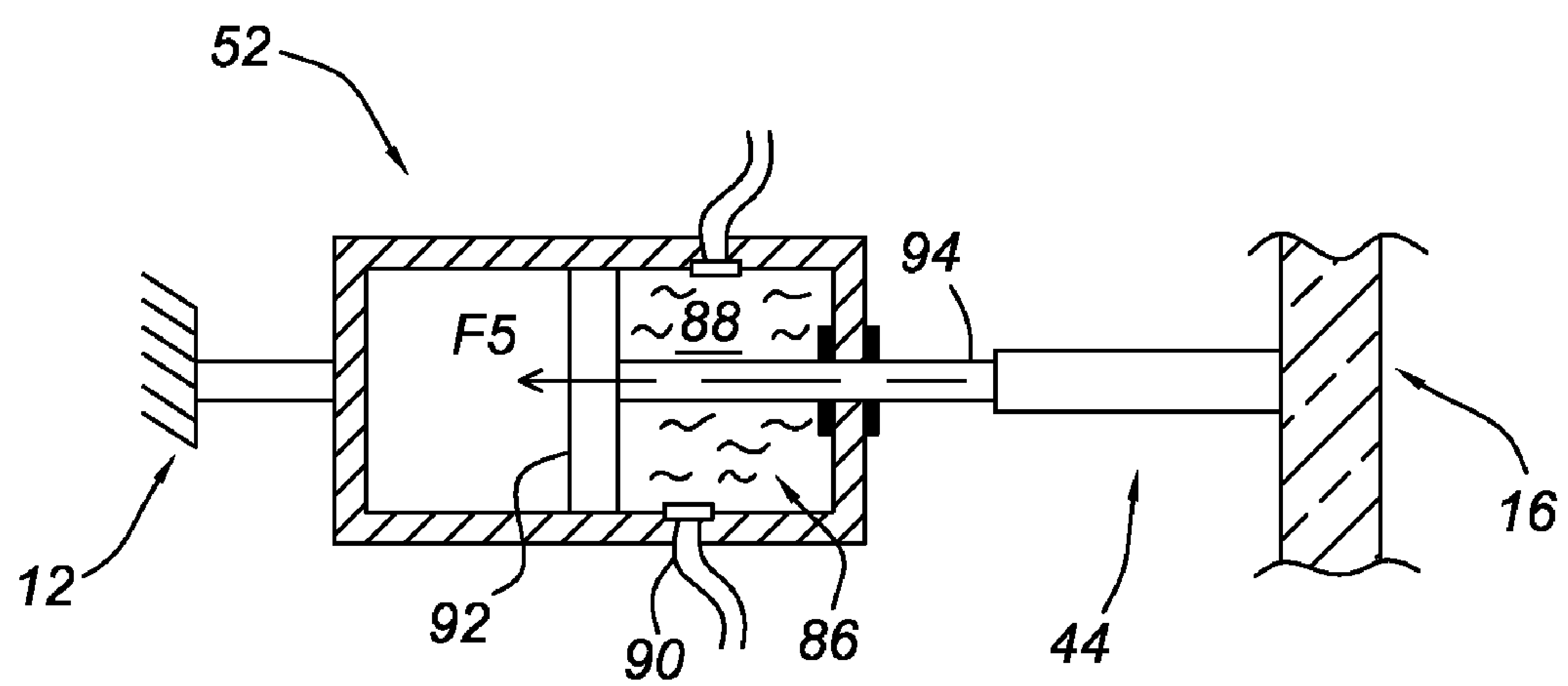
52
94
F5
88
12
92
90
86
44
16

FIG. 5b

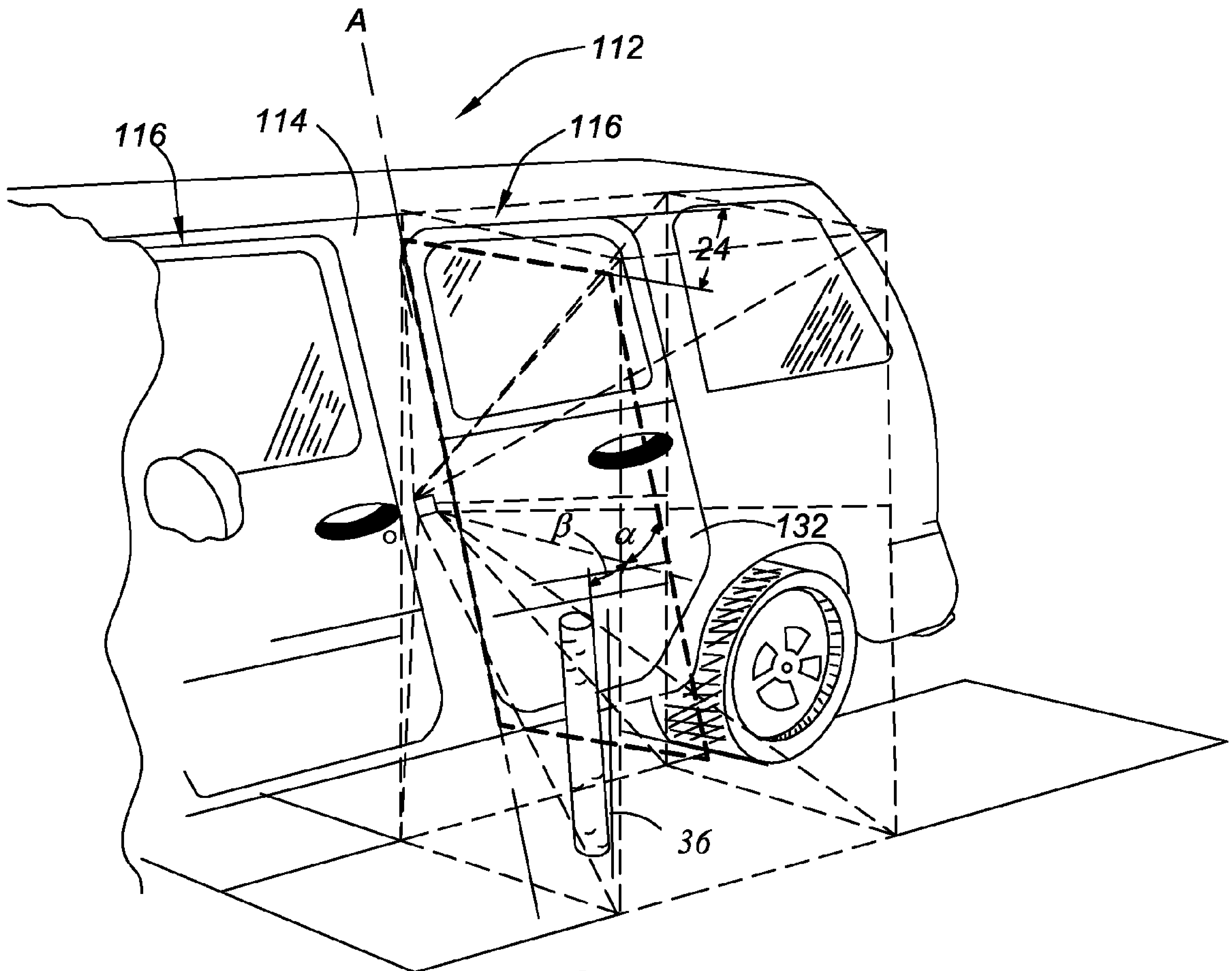
A
112
116
114
116
24
β
α
132
36

FIG. 6a

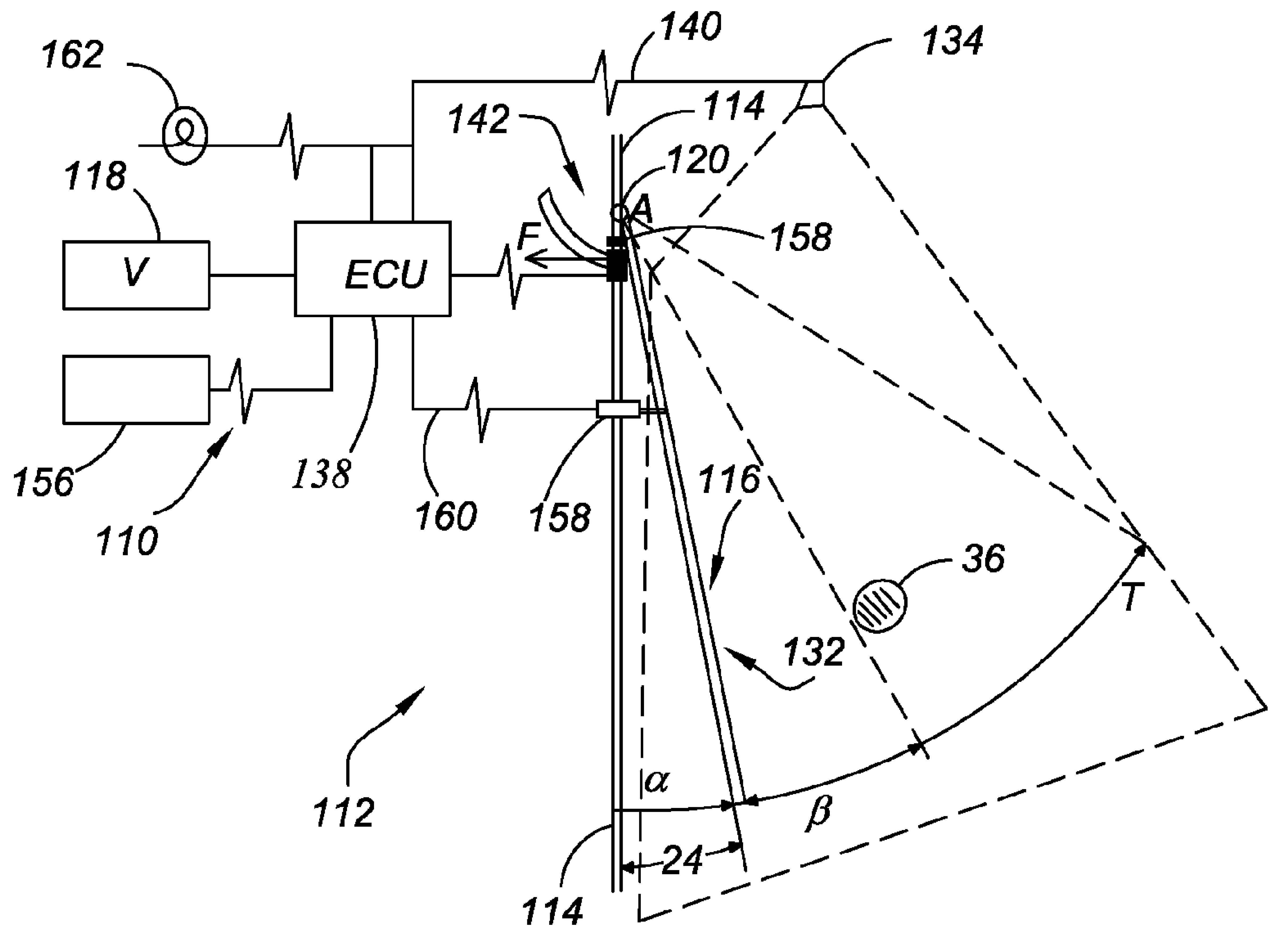
162
140
134
142
114
120
118
A
F
158
V
ECU
156
110
138
160
158
116
36
T
132
112
α
β
24
114

FIG. 6b

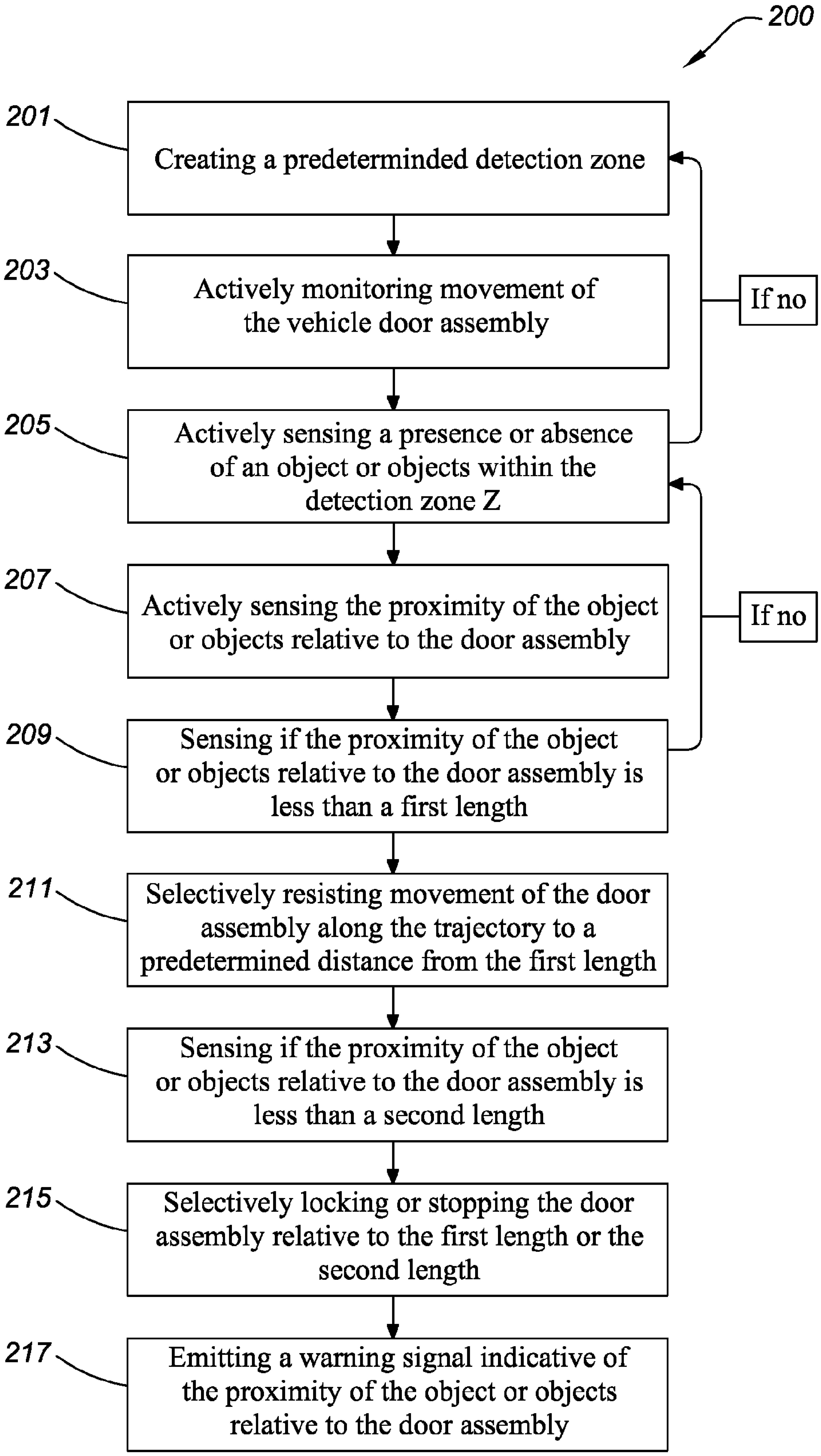
200
201
Creating a predeterminded detection zone
203
Actively monitoring movement of the vehicle door assembly
If no
205
Actively sensing a presence or absence of an object or objects within the detection zone Z
207
Actively sensing the proximity of the object or objects relative to the door assembly
If no
209
Sensing if the proximity of the object or objects relative to the door assembly is less than a first length
211
Selectively resisting movement of the door assembly along the trajectory to a predetermined distance from the first length
213
Sensing if the proximity of the object or objects relative to the door assembly is less than a second length
215
Selectively locking or stopping the door assembly relative to the first length or the second length
217
Emitting a warning signal indicative of the proximity of the object or objects relative to the door assembly

FIG. 7

OBSTRUCTION DETECTION DEVICE FOR VEHICLE DOOR AND METHOD

TECHNICAL FIELD OF THE INVENTION

The present invention relates to obstruction detection devices for vehicle doors.

BACKGROUND OF THE INVENTION

Since the early inception of the automobile (also referred to as a motor vehicle) a vehicle door or door assembly has been incorporated into the vehicle design to protect the vehicle's contents and allow for vehicle ingress and egress. The door assembly is generally hinged to the vehicle body so that the door may be pivoted to an open position and pivoted to a closed position, and will often include a latching mechanism for securing the door in the closed position. The size, weight, geometry, and opening trajectory of the door assembly will vary from vehicle to vehicle.

A standard motor vehicle door assembly includes a frame with an inner front-frame member for forming a front edge of the door assembly; an inner rear-frame member for forming a rear edge of the door assembly; a waist reinforcing member for connecting the front frame member with the rear frame member; and a hinge member for connecting the door assembly to the vehicle. The door assembly also includes a shell or housing and a window opening where a window frame is connected to the door housing. The door housing itself can be limited to two primary components: an outer panel and an inner panel or lining. Depending on the size, weight, geometry, and trajectory range for opening the door assembly, the door shell is susceptible to significant damage caused by inadvertent contact with undetected obstructions or objects foreign to the vehicle while the door assembly is moving. Large sport utility vehicles ("SUVs") and other large vehicles tend to have large doors with large door openings angles, which greatly exacerbates the potential of doing damage to the door shell while moving the door assembly from the fully closed to the fully open position.

SUMMARY OF THE INVENTION

An obstruction detection device for a vehicle door is provided that is configured to actively monitor the presence or absence, and corresponding proximity of an object relative to a vehicle door assembly, and vary the vehicle door's opening angle, or stop the vehicle door from moving, to prevent contact with the object, while providing the largest possible opening for vehicle ingress and egress. A method is also provided for selectively varying the resistance to movement of a vehicle door assembly to prevent inadvertent contact between the door assembly and the object, while providing the largest possible opening for vehicle ingress and egress.

In accordance with one aspect of the present invention, there is provided a vehicle door obstruction detection device for a motor vehicle. The obstruction detection device includes a controller operatively connected to an actuator and at least one sensor. The sensor is configured to monitor and transmit signals to the controller indicative of the presence and proximity of an object relative to the door assembly. The actuator is controlled by the controller in response to the sensor signals, and configured to apply a selectively variable force that restricts and/or stops the rotation of the vehicle door assembly with respect to the vehicle body when the door is a predetermined distance from the object, thereby preventing inadvertent contact with the object, while providing the largest possible opening for vehicle ingress and egress.

In accordance with a second embodiment of the present invention, a vehicle is provided. The vehicle comprises a vehicle body, a door assembly rotatably connected therewith, a power source disposed on the vehicle body, and a controller operatively connected to the power source and an actuator, at least one sensor, a transducer, and an interface. The actuator is controlled by the controller and configured to apply a selectively variable force to the door assembly thereby restricting its rotation with respect to the vehicle body. The at least one sensor is configured to monitor and transmit signals to the controller indicative of the presence and corresponding proximity of an object relative to the door assembly. The transducer is configured to measure and transmit signals to the controller indicative of the rotational displacement of the vehicle door assembly along a predetermined trajectory. The controller instructs the actuator to apply the selectively variable force to the door assembly, or to lock the vehicle door assembly at any position along the trajectory, in response to the sensor signals and/or the transducer signals, thereby preventing inadvertent contact with the object, while providing the largest possible opening for vehicle entry and egress. Finally, the interface allows users of the door assembly to control the actuator's application of the selectively variable force to restrict or stop the rotation of the door assembly with respect to the vehicle body.

The obstruction detection device in accordance with the above-described embodiments could be applied to any type of door assembly (i.e., a swing door or trunk lid, an engine hood, a sliding door, a lift gate, a tailgate, a winged door, or the like) on various types of motorized vehicles—cars, trucks and SUVs. Additionally, the sensor(s) could be functionally disposed at any of a number of locations on the motor vehicle (i.e., the vehicle body, the door assemblies, or the rear view mirrors) in accordance with the above-described embodiments. Finally, the means for restricting the rotation of the door assembly could be any of numerous functionally operative devices, such as a friction device or damper, an electromagnetic device or damper, a magnetorheological fluid device or damper, and/or a hydraulic device or damper.

An additional aspect of the present invention is to provide an improved method for selectively varying the movement of a vehicle door assembly to prevent inadvertent contact with obstructions, while providing the largest possible opening for vehicle ingress and egress. The method includes the steps of: creating a predetermined detection zone; monitoring the movement of the vehicle door assembly within the detection zone; sensing a presence or absence of an object within the detection zone; sensing a corresponding proximity of the object relative to the door assembly in response to movement of the door assembly along a predetermined trajectory; sensing if the proximity of the object is less than a predetermined first length; and responding to the proximity being less than the predetermined first length by selectively resisting, or controlling, the movement of the door assembly along the trajectory, and limiting the door trajectory to a point sufficiently less than the first length so as to prevent impact with the object, but sufficiently close to the first length to maximize the movement of the door assembly short of the predetermined length in order to provide the largest opening for vehicle ingress and egress without such impact.

The method presented above may further include locking the door assembly at any position along the trajectory at a point sufficiently less than a second predetermined length so as to eliminate any impact with the object, but sufficiently close to the second length in order to maximize the movement of the door assembly to a point just short of the second predetermined length to provide the largest opening for vehicle ingress and egress without such impact. As a final step, the method may include the emission of a visual, acoustic, or physical warning signal which indicates the proximity of objects relative to the door assembly.

The above features and advantages, and other features and advantages of the present invention, will be readily apparent from the following detailed description of the preferred embodiments and best modes for carrying out the invention when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1***a* is a fragmentary perspective view of a vehicle with an obstruction detection device assembled and installed thereupon in accordance with a first embodiment of the present invention;

FIG. **1***b* is a schematic top plan view of the obstruction detection device and door assembly trajectory of FIG. **1***a* in accordance with the first embodiment of the present invention;

FIG. **2***a* is a schematic top plan view of the obstruction detection device and door assembly trajectory of FIGS. **1***a* and **1***b* in accordance with a second embodiment of the present invention;

FIG. **2***b* is a schematic cross sectional view of the actuator assembly of FIG. **2***a* in accordance with the second embodiment of the present invention;

FIG. **3***a* is a schematic top plan view of the obstruction detection device and door assembly trajectory of FIGS. **1***a* and **1***b* in accordance with a third embodiment of the present invention;

FIG. **3***b* is a schematic cross sectional view of the actuator assembly of FIG. **3***a* in accordance with the third embodiment of the present invention;

FIG. **4***a* is a schematic top plan view of the obstruction detection device and door assembly trajectory of FIGS. **1***a* and **1***b* in accordance with a fourth embodiment of the present invention;

FIG. **4***b* is a schematic cross sectional view of the actuator assembly of FIG. **3***a* in accordance with the fourth embodiment of the present invention;

FIG. **5***a* is a schematic top plan view of the obstruction detection device and door assembly trajectory of FIGS. **1***a* and **1***b* in accordance with a fifth embodiment of the present invention;

FIG. **5***b* is a schematic cross sectional view of the actuator assembly of FIG. **3***a* in accordance with the fifth embodiment of the present invention;

FIG. **6***a* is a fragmentary perspective view of a motor vehicle with an obstruction detection device assembled and installed thereupon in accordance with a sixth embodiment of the present invention;

FIG. **6***b* is schematic a top plan view of the obstruction detection device and door assembly trajectory of FIG. **6***a* in accordance with the sixth embodiment of the present invention; and

FIG. **7** is a flow chart illustrating a method for selectively varying the movement of a vehicle door assembly in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the figures, wherein like reference numbers refer to like components throughout the several views, an obstruction detection device, shown generally as **10**, is illustrated in accordance with a first embodiment of the present invention. FIG. **1***a* is a partial fragmentary view of a motor vehicle **12**, having a vehicle body **14**, upon which a door assembly **16** is rotatably mounted.

The door assembly **16** is illustrated as a side door, specifically a rear passenger door; however, any vehicle door is contemplated within the spirit and scope of the present invention, including swing doors or trunk lids, engine hoods, sliding side doors, lift gates, tailgates, winged doors or the like.

The door assembly **16** includes a door frame **18**, which, for example, is pivotally connected to the vehicle body **14** about a pivot axis, identified as "A", via door hinge **20** (shown in FIG. **1***b*.) The door assembly **16** also includes a door latching mechanism **22** for securing the door in a closed position, thereby eliminating opening **24**, defined as the space between the vehicle body **14** and an open position, shown by hidden lines in FIG. **1***a*, of the door assembly **16** (as best seen in FIG. **1***b*.) Further, the door assembly **16** may be provided with a window **26**. The size, weight, geometry, and maximum opening angle, "α", of the door assembly **16** will vary from vehicle to vehicle. By way of example, large SUV's and sedans tend to have large door assemblies with large door openings angles.

The door assembly **16** further includes a door shell **28**, defined by an outer panel or face **32** opposing an inner panel or face **30** generally facing the interior of the motor vehicle, as best seen in FIG. **1***b*. The door shell **28** encloses the components of the door assembly **16** (not shown) and may be formed from stamped sheet metal and/or a rigid polymer such as ABS plastic, and may include foam, cushioning, vinyl, fabric, wood, metal or the like, or ornamental indicia where desired to provide comfort and an aesthetic styling and design appeal to the vehicle passenger, hereinafter also referred to as an occupant or user (not shown).

Referring again to FIG. **1***a*, the obstruction detection device **10** includes at least one sensing mechanism or sensor **34**. FIG. **1***a* depicts the obstruction detection device **10** consisting of a single sensor **34** disposed on the vehicle body **14** at pillar **35**, sometimes referred to as a B-pillar. However, also in accordance with the present invention, the obstruction detection device **10** may include multiple sensors **34**; the sensors **34** being disposed at any of a number of functional locations, such as the door assemblies **16**, a rear view mirror **19**, or other locations on the vehicle body **14**. Furthermore, the sensor **34** may be any of a multitude of sensing mechanisms. By way of example, the sensor **34** could be an ultrasonic sensor, a laser-based radar, an infrared sensor, a geomagnetic sensor, a light-emitting device, a composite sensor, or the like within the spirit and scope of the present invention.

Referring to FIGS. **1***a*, **2***a*, **3***a*, **4***a* and **5***a*, the sensor **34** produces a detection zone Z, which envelops the door assembly **16** at any point along a predetermined trajectory T. The detection zone Z is configured so the sensor **34** can detect the presence or absence of an object **36**, sometimes referred to as an obstruction(s), and actively monitor the corresponding proximity, identified as "β", of the object(s) **36** relative to the door assembly **14**. Preferably, the proximity β is measured as the shortest angular distance between the outer face **32** of the door assembly **16** and the object(s) **36**.

The sensor **34** is operatively connected to a controller **38** such that the sensor **34** can transmit a sensor signal or signals **40** indicative of the presence and proximity β of the obstructions **36**. Those skilled in the art will recognize and understand that the means of communication between the sensor **34** and controller **38** is not restricted to the use of electric cables ("by wire") for communication, but may be, for example, by radio frequency and other wireless technology, or by electro-mechanical communication.

The controller **38** processes the signal **40** generated by the sensor **34** to first determine if an obstruction(s) **36** is within the zone Z. If an obstruction **36** is detected, the controller **38** then determines the proximity P of the obstruction(s) **36** with respect to the outer panel **32** of the door shell **28**. The controller **38** then determines if the obstruction(s) **36** is less than or equal to a predetermined proximal angular distance L**1** from the outer panel **32** in response to movement of the door assembly **16** along a trajectory T of predetermined length. The controller **38** can employ various methods of logic to process the sensor signals **40** and establish the distance L**1** (i.e., preset system parameters, statistics, "fuzzy logic", and the like.)

The detection zone Z is depicted in FIG. **1***a* as a cuboid. However, it is contemplated within the scope and spirit of the present invention that the detection zone Z may consist of any functional shape. Furthermore, the objects or obstructions **36**, depicted in FIG. **1***a* as a single concrete pillar, may consist of any object or combination of objects foreign to the vehicle **12**, such as other vehicles, a garage wall, a parking block, parking meters, uneven ground clearances, and/or pedestrians.

Referring to FIGS. **2***a*, **3***a*, **4***a* and **5***a*, an actuator **42** is operatively connected to the controller **38**, such that the controller **38** can selectively activate and deactivate the actuator **42** in response to the sensor signals **40**. The actuator **42** is configured to apply a selectively variable force or resistance, identified as "F", which restricts the rotation of the vehicle door assembly **16** with respect to the vehicle body **14**. The resistance F can be varied to gradually restrict or slow the movement of the door assembly **16** relative to the object(s) **36**, for example, as a function of the proximity β, the opening angle α, and/or the angular speed ω of the door assembly **16**. In addition, the controller **38** may also selectively instruct the actuator **42** to lock or stop the vehicle door assembly **16** at any position along trajectory T to completely eliminate the potential for unwanted and/or inadvertent contact between the door assembly **16** and the object(s) **36**.

Now referring to FIGS. **3***a* and **3***b*, the actuator **42** preferably comprises a check link **44** and a magnetorheological fluid device or damper **46**. A piston assembly, shown generally as **64**, is connected to a piston rod **66** and is disposed within a housing tube **68**. The piston rod **66** extends through the opening **70**. The piston assembly **64** includes a piston body **72** that carries a band of low friction material **74** for engaging an inner damper face **76**. This provides a mechanism for fluid separation between extension chamber **78** and compression chamber **80**. The chamber **78** is filled with a magnetorheological fluid, shown generally as **82**.

The magnetorheological fluid **82** is a type of "smart fluid", wherein the viscoelastic properties of the magnetorheologic fluid **82** can be selectively modified by applying a magnetic field of sufficient strength. Microscopic magnetic dipoles (normally fine iron) are randomly disposed and suspended in a non-magnetic fluid (hydraulic oils and the like). The applied magnetic field causes these small magnets to align and form strings, resulting in an increase in the fluid's viscosity (a rheology change). Notably, the yield stress of a magnetorheological fluid can be manipulated by varying the intensity of the magnetic field. Put another way, the fluid's ability to transmit force can be controlled with an electromagnet. As illustrated in FIGS. **3***a* and **3***b*, the increase in viscosity applies a resistance or viscoelastic damping force F**3** to the piston assembly **64**, which is transferred to the check link **44** via piston rod **66**, thereby restricting rotation of the vehicle door assembly **16** with respect to the vehicle body **14**.

The actuator **42** may also include a check link **44** in combination with a friction device, shown generally as **48** in FIGS. **2***a* and **2***b*. The friction device **48** is configured to apply a selectively variable normal force N, via friction pads **54**, to the check link **44**, producing a frictional resistance or damping force F on the check link **44**, thereby restricting rotation of the vehicle door assembly **16** with respect to the vehicle body **14**. The drag coefficient C_f on the check link **44** can be manipulated by varying the intensity of the force N, applied normal to the direction of translation of the structural check link **44**.

Alternatively, the actuator **42** used in the obstruction detection device **10** may include the structural check link **44** in combination with an electro-magnetic device or damper, shown generally as **50** in FIGS. **4***a* and **4***b*. The electro-magnetic device **50** is configured to apply a selectively variable magnetic resistance or damping force F**4** to the structural check link **44**, thereby restricting the movement of the vehicle door assembly **16** with respect to the vehicle body **14**. Magnetic damping is achieved when a conductor **84**, for example a copper plate, movably disposed in housing **85**, moves through a time varied magnetic field produced by permanent magnets **87**. According to Maxwell's Laws, a time varying magnetic field will produce an electric field which causes circulating ("eddy") currents to flow in the conductor **84**. These currents dissipate energy as they flow through the resistance of the conductor, resulting in a drag force F**4** on the conductor **84**.

It is also contemplated within the scope of the embodiments described above to utilize the structural check link **44** in combination with a hydraulic damper or device, shown generally as **52** in FIGS. **5***a* and **5***b*. The hydraulic device **52** is configured to apply a selectively variable hydraulic resistance or damping force F**5** to the structural check link **44**, thereby restricting rotation of the vehicle door assembly **16** with respect to the vehicle body **14**. Variable hydraulic damping is achieved through the manipulation (introduction and/or evacuation) of hydraulic fluid, shown generally as reference numeral **86** in FIG. **5***b*, into and out of a compression chamber **88**. As fluid is fed through a first hose **90**, the compressible nature of the hydraulic fluid **86** decreases, creating more hydraulic pressure, and a larger force F**5**, on piston head **92**, which is translated to the structural check link **44** via piston rod **94**. Conversely, the force F**5** on check link **44** can be reduced by evacuating (or bleeding) hydraulic fluid **86** from compression chamber **88**, thereby reducing the hydraulic pressure on piston head **92**.

Those skilled in the art will recognize and understand that there are additional mechanisms by which the door opening angle α can be controlled, such as electro-mechanical devices, piezoelectric devices, and/or "smart materials", incorporated into the obstruction detection device **10**, to apply the selectively variable force F and thereby restrict movement of the vehicle door assembly **16** with respect to the vehicle body **14**. It should also be noted that the actuator **42** need not include a traditional door check link to apply the selectively variable force F to the door assembly **16**, but may incorporate any functional means for allowing the motion of the door assembly **16** to be controlled by the various embodiments described herein.

Referring to FIGS. **2***a*, **3***a*, **4***a*, and **5***a*, the obstruction detection device **10** preferably includes a user interface **56**, which is configured to allow users of the door assembly **16** to control the obstruction detection device **10** and corresponding movement of the door assembly **16**. The interface **56** is preferably configured to allow users to manipulate the selectively variable force F, thereby increasing or decreasing the intensity of the damping force F being applied to the door assembly **16**. The user interface **56** may be further configured to allow users of the door assembly **16** to selectively activate or deactivate the actuator **42**, such that the vehicle door assembly **16** may be selectively stopped or locked in position at any point along trajectory T, or selectively allowed to move freely relative to the vehicle body **14**, respectively. It is also contemplated within the scope and spirit of the present invention that the user interface **56** recognize a minimum override force (not shown) applied by a user of the door assembly **16** by which the controller **38** will deactivate the actuator **42**, thereby allowing free motion of the door assembly **16**.

The obstruction detection device **10** may further include a transducer, illustrated as element **58** in FIGS. **2***a*, **3***a*, **4***a*, and **5***a*. The transducer **58** is configured to actively measure the rotational displacement or angle α and angular speed ω of the vehicle door assembly **16** with respect to the vehicle body **14**, and transmit a signal or signals, designated as element **60**, to the controller **38** indicative thereof. The transducer **58** is operatively connected to the controller **38**, such that the controller **38** processes the transducer signal **60** and instructs the actuator **42** to apply a selectively variable force F to vary the rotational displacement α of the door assembly **16**, or stop the door assembly **16** at any point along the trajectory T.

Those skilled in the art will recognize and understand that the means for communicating between the interface **56** and the controller **38** or the transducer **58** and the controller **38**, is not restricted to the use of electric cables ("by wire"), but may, for example, be by radio frequency or other wireless technology, and/or by electro-mechanical communication.

Preferably, the obstruction detection device **10** also includes a warning signal **62** configured to notify the vehicle occupant of the proximity of the object(s) **38** relative to the door assembly **16**. The warning signal **62** might be visual (e.g., a flashing light), acoustic (e.g., a beeping sound), or physical (e.g., a vibrating member.)

According to yet another embodiment of the present invention, illustrated in FIGS. **6***a* and **6***b*, an entire vehicle **112** is provided, including a vehicle body **114**, a door assembly **116** (with all the features of the vehicle door assembly **16** illustrated in FIG. **1***a*) rotatably connected therewith to rotate about axis A via hinge **120**, and a controller **138**. The controller **138** is operatively connected to a power source **118**, an actuator **142**, an interface **156**, at least one sensor or sensing mechanism **134**, and a transducer **158**. The actuator **142** is controlled by the controller **138** and configured to apply a selectively variable force F to the door assembly **116**, thereby restricting its movement or rotation α relative to the vehicle body **114**. The at least one sensor **134** is configured to actively monitor and transmit a signal or signals **140** to the controller **138** indicative of the presence and relative proximity of an object **36**, also referred to as obstructions, with respect to the door assembly **116**. The transducer **158** is configured to actively measure and transmit a signal or signals **160** to the controller **138** indicative of the rotational displacement α and angular speed ω of the vehicle door assembly **116**. The controller **138** instructs the actuator **142** to apply the selectively variable force F to the door assembly **116**, or to lock the vehicle door assembly **116** at any position along the trajectory T, in response to the sensor signal(s) **140** and or the transducer signal(s) **160**, thereby preventing or eliminating inadvertent contact between the door assembly **116** and the obstructions **36**, while providing the largest possible opening **24** for vehicle ingress and egress.

The user interface **156** allows users of the vehicle door assembly **116** to control the actuator **142** and corresponding application of the selectively variable force F. As such, the user may selectively restrict the movement of the door assembly **116** with respect to the vehicle body **114**, lock the door assembly **116** at any position along trajectory T, and or disengage the actuator **142**, thus allowing unfettered movement of the door assembly **116**. It is preferable that the vehicle **112** also include a warning signal **162**, with the same functional features as signal **62**, recited above.

A method for selectively varying the movement of a vehicle door assembly **200**, as described below, may be employed in the respective embodiments described above; the method **200** being described with respect to the structure illustrated in FIGS. **1***a* through **6***b*. However, the method **200** may also be applied to other obstruction detection devices for various motor vehicle door assemblies. Referring to FIG. **7**, the method **200** includes step **201**, wherein detection zone Z is created to envelop the door assembly **16**, **116** at any point during movement along trajectory T. Step **203** includes actively monitoring movement of the vehicle door assembly **16**, **116** along trajectory T, within zone Z. The method **200** also includes actively sensing the presence or absence of the object **36** within the detection zone Z, as step **205**. If no object **36** are detected within zone Z, the iteration of method **200** begins again at step **201**. It should be noted here that steps **203** and **205** are interchangeable.

If an object **36** is detected within the zone Z, the sensor or sensors **34**, **134** will thereafter actively monitor the proximity β of the object **36** relative to the outer face **32**, **132** of the door assembly **16**, **116** in response to the movement of the door assembly **16**, **116** along trajectory T, as step **207**. Step **209** requires sensing if the proximity β of the objects or obstructions **36** is less than a predetermined first length L**1**. If not, the method **200** returns to step **205**. If yes, step **211** requires the obstruction detection device **10**, **110** to respond to the proximity β of the obstructions **36** being less than the first length L**1** by selectively resisting the movement of the door assembly **16**, **116** along the trajectory T to a point sufficiently less than the first length L**1** so as to prevent impact between the door assembly **16**, **116** with the object **36**. Step **211** further includes instructing the actuator **42**, **142** to allow the door assembly **16**, **116** to rotate to a point sufficiently close to the first length L**1** in order to provide the largest opening **24**, **124** between the door assembly **16**, **116** and the vehicle body **14**, **114** for entry into and egress from the vehicle **12**, **112**. The controller **38** can employ various methods of logic to process the sensor signals **40**, establish the first length L**1**, and vary the movement of the door assembly **16** (i.e., preset system parameters, statistics, "fuzzy logic", and the like.)

The method **200** preferably also includes step **213-217**. Step **213** requires sensing if the proximity β of the objects or obstructions **36** is less than a predetermined second length L**2**, which is preferably less than the first length L**1**. Step **215** requires the obstruction detection device **10**, **110** to respond to the proximity β of the obstructions **36** being less than the second length L**2** by locking or stopping the door assembly **16**, **116** at a position along the trajectory path T at a point sufficiently less than the second predetermined length L**2**, so as to eliminate any possibility of impact between the door assembly **16**, **116** and the object **36**. Step **213**, similar to step **211**, allows the door assembly **16**, **116** to rotate to a point sufficiently close to the second length L**2** to maximize the movement of the door assembly **16**, **116** to a point just shy of the second predetermined length L**2** to provide the largest opening **24**, **124** for ingress to and egress from the vehicle **16**, **116**. Finally, method **200** preferably includes, as step **217**, emitting a warning signal which is configured to notify vehicle occupants of the proximity β of the object **36** relative to the door assembly **16**, **116**.

The terms "proximity" and "length" used in the appended claims may refer to angular or linear distances or lengths within the scope of the present invention. In other words, the sensed or determined proximities and lengths may be measured linearly from a surface, or angularly with the pivoting movement of the respective door.

While the best modes for carrying out the invention have been described in detail, those familiar with the art to which the instant invention relates will recognize various alternative designs and embodiments for practicing the invention within the scope of the appended claims. As set forth in the claims, various features shown and described in accordance with the various different embodiments of the invention as illustrated may be combined.

The invention claimed is:

1. An obstruction detection device for a motor vehicle having a vehicle body and a vehicle door assembly being selectively rotatable about an axis with respect to the vehicle body, the obstruction detection device comprising:

a controller;

at least one sensor operatively connected to the controller and configured to monitor the presence and proximity of an object relative to the vehicle door assembly and to transmit signals indicative thereof to the controller; and

an actuator operatively connected to and controlled by the controller in response to the sensor signals and configured to apply a selectively variable force restricting the rotation of the vehicle door assembly about the axis with respect to the vehicle body when the door assembly is a predetermined distance from the object.

2. The obstruction detection device of claim **1**, further comprising:

an interface configured to allow users of the vehicle door assembly to control the actuator.

3. The obstruction detection device of claim **2**, wherein the interface is further configured to allow users of the vehicle door assembly to selectively lock the vehicle door assembly at any position along the trajectory.

4. The obstruction detection device of claim **1**, further comprising:

a transducer operatively connected to the controller and configured to measure the displacement of the vehicle door assembly along a trajectory and transmit signals indicative thereof to the controller, wherein the controller is further configured to selectively command the actuator to lock the vehicle door assembly at any position along the trajectory in response to at least one of the transducer signals and the sensor signals.

5. The obstruction detection device of claim **1**, wherein the actuator comprises a friction device configured to apply a selectively variable frictional resistance to the vehicle door assembly thereby restricting movement of the vehicle door assembly with respect to the vehicle body.

6. The obstruction detection device of claim **1**, wherein the actuator comprises an electro-magnetic device configured to apply a selectively variable magnetic resistance to the vehicle door assembly thereby restricting movement of the vehicle door assembly with respect to the vehicle body.

7. The obstruction detection device of claim **1**, wherein the actuator comprises a magnetorheological fluid device configured to apply a selectively variable viscoelastic resistance to the vehicle door assembly thereby restricting movement of the vehicle door assembly with respect to the vehicle body.

8. The obstruction detection device of claim **1**, wherein the actuator comprises a hydraulic device configured to apply a selectively variable hydraulic resistance to the vehicle door assembly thereby restricting movement of the vehicle door assembly with respect to the vehicle body.

9. The obstruction detection device of claim **1**, wherein the vehicle door assembly is any of a swing door or trunk lid, an engine hood, a sliding door, a lift gate, a tailgate, or a winged door.

10. The obstruction detection device of claim **9**, wherein the at least one sensor is disposed on the vehicle door assembly.

11. The obstruction detection device of claim **1**, further comprising:

a warning signal indicative of the proximity of the object relative to the door assembly.

12. A vehicle, comprising:

a vehicle body;

a door assembly rotatably connected with respect to the vehicle body;

a power source disposed on the vehicle body;

a controller disposed on the vehicle body and operatively connected to the power source;

an actuator operatively connected to and controlled by the controller and configured to apply a selectively variable force restricting the rotation of the door assembly with respect to the vehicle body;

an interface configured to allow users of the door assembly to control the actuator;

at least one sensor operatively connected to the controller and configured to monitor the presence and proximity of an object relative to the door assembly and to transmit signals indicative thereof to the controller; and

a transducer operatively connected to the controller and configured to measure the rotational displacement of the door assembly along a trajectory and transmit signals indicative thereof to the controller, wherein the controller instructs the actuator to apply the selectively variable force to the door assembly in response to at least one of the transducer signals and the sensor signals.

13. The vehicle of claim **12**, wherein the controller is further configured to selectively command the actuator to lock the door assembly at any position along the trajectory in response to at least one of the transducer signals and the sensor signals.

14. The vehicle of claim **12**, wherein the interface is further configured to allow users of the door assembly to selectively lock the door assembly at any position along the trajectory and override the actuator thereby allowing free motion of the door assembly with respect to the vehicle body.

15. The vehicle of claim **12**, wherein the actuator comprises a structural check link and a friction device configured to apply a selectively variable frictional resistance to the check link thereby restricting rotation of the door assembly with respect to the vehicle body.

16. The vehicle of claim **12**, wherein the actuator comprises a structural check link and an electro-magnetic device configured to apply a selectively variable magnetic resistance to the structural check link thereby restricting rotation of the door assembly with respect to the vehicle body.

17. The vehicle of claim **12**, wherein the actuator comprises a structural check link and a magnetorheological fluid device configured to apply a selectively variable viscoelastic resistance to the structural check link thereby restricting rotation of the door assembly with respect to the vehicle body.

18. The vehicle of claim **12**, wherein the actuator comprises a structural check link and a hydraulic device configured to apply a selectively variable hydraulic resistance to the structural check link thereby restricting rotation of the door assembly with respect to the vehicle body.

19. The vehicle of claim **12**, wherein the vehicle door assembly is any of a swing door or trunk lid, an engine hood, a sliding door, a lift gate, a tailgate, or a winged door.

20. The vehicle of claim **19**, wherein the at least one sensor is disposed on the door assembly.

21. The vehicle of claim **19**, wherein the at least one sensor is disposed on the vehicle body.

22. The vehicle of claim **19**, further comprising:

a vehicle rear view mirror, wherein the at least one sensor is disposed on the rear view mirror.

23. The vehicle of claim **12**, further comprising:

a warning signal indicative of the proximity of the object relative to the door assembly.

24. A method of selectively varying the movement of a vehicle door assembly, comprising:

creating a predetermined detection zone;

monitoring movement of the vehicle door assembly within the detection zone;

sensing a presence or absence of an object within the detection zone;

sensing a proximity of the object relative to the door assembly in response to movement of the door assembly along a predetermined trajectory;

sensing if the proximity of the object is less than a predetermined first length; and

responding to the proximity being less than the first length by selectively resisting movement of the door assembly along the trajectory to a point sufficiently less than the first length so as to prevent impact between the door assembly and the object, and sufficiently close to the first length to maximize the movement of the door assembly short of the first length to provide the largest opening for vehicle ingress and egress without such impact.

25. The method of claim **24**, further comprising:

sensing if the proximity of the object is less than a predetermined second length; and

responding to the proximity being less than the second length by locking the door assembly at any position along the trajectory at a point sufficiently less than the second length so as to eliminate any impact with the object, and sufficiently close to the second length to maximize the movement of the door assembly short of the second length to provide the largest opening for vehicle ingress and egress without any impact.

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